

# PATENT COOPERATION TREATY

# PCT

## INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY


(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

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Applicant's or agent's file reference 35675 PC 01	<b>FOR FURTHER ACTION</b>  See Form PCT/PEA/416	
International application No. PCT/DK2004/000775	International filing date (day/month/year) 08.11.2004	Priority date (day/month/year) 07.11.2003
International Patent Classification (IPC) or national classification and IPC G06F1/20		
Applicant ASETEK AS		
<p>1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 6 sheets, including this cover sheet.</p> <p>3. This report is also accompanied by ANNEXES, comprising:</p> <p style="margin-left: 20px;">a. <input checked="" type="checkbox"/> sent to the applicant and to the International Bureau a total of 36 sheets, as follows:</p> <p style="margin-left: 40px;"><input checked="" type="checkbox"/> sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).</p> <p style="margin-left: 40px;"><input type="checkbox"/> sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.</p> <p style="margin-left: 20px;">b. <input type="checkbox"/> (sent to the International Bureau only) a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).</p>		
<p>4. This report contains indications relating to the following items:</p> <p><input checked="" type="checkbox"/> Box No. I Basis of the opinion</p> <p><input type="checkbox"/> Box No. II Priority</p> <p><input type="checkbox"/> Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</p> <p><input type="checkbox"/> Box No. IV Lack of unity of invention</p> <p><input checked="" type="checkbox"/> Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</p> <p><input type="checkbox"/> Box No. VI Certain documents cited</p> <p><input type="checkbox"/> Box No. VII Certain defects in the international application</p> <p><input type="checkbox"/> Box No. VIII Certain observations on the international application</p>		
Date of submission of the demand  22.09.2005	Date of completion of this report  12.12.2005	
Name and mailing address of the international preliminary examining authority:   European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Authorized Officer  Arranz, J  Telephone No. +31 70 340-4870	



# INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.  
PCT/DK2004/000775

**Box No. I    Basis of the report**

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.
- ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
- ☐ international search (under Rules 12.3 and 23.1(b))
- ☐ publication of the international application (under Rule 12.4)
- ☐ international preliminary examination (under Rules 55.2 and/or 55.3)
2. With regard to the **elements\*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

**Description, Pages**

1-24 received on 25.10.2005 with letter of 20.10.2005

## Claims, Numbers

1-69 received on 25.10.2005 with letter of 20.10.2005

## Drawings, Sheets

1/14-14/14 as originally filed

- ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing
3. ☐ The amendments have resulted in the cancellation of:
- ☐ the description, pages
  - ☐ the claims, Nos.
  - ☐ the drawings, sheets/figs
  - ☐ the sequence listing (*specify*):
  - ☐ any table(s) related to sequence listing (*specify*):
4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
- ☐ the description, pages
  - ☐ the claims, Nos.
  - ☐ the drawings, sheets/figs
  - ☐ the sequence listing (*specify*):
  - ☐ any table(s) related to sequence listing (*specify*):

\* If item 4 applies, some or all of these sheets may be marked "superseded."

**INTERNATIONAL PRELIMINARY REPORT  
ON PATENTABILITY**

International application No.  
PCT/DK2004/000775

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**Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

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1. Statement

Novelty (N)	Yes: Claims	2-69
	No: Claims	1
Inventive step (IS)	Yes: Claims	
	No: Claims	1-69
Industrial applicability (IA)	Yes: Claims	1-69
	No: Claims	

2. Citations and explanations (Rule 70.7):

**see separate sheet**

Re Item V.

1 Reference is made to the following documents:

- D1 : US 6 019 165 A (BATCHELDER ET AL) 1 February 2000 (2000-02-01)
- D2 : US 6 263 957 B1 (CHEN SHIAW-JONG S ET AL) 24 July 2001 (2001-07-24)
- D3 : US 2003/151895 A1 (ZUO JON) 14 August 2003 (2003-08-14)
- D4: US-A-4 898 579 (GROSHONG ET AL) 6 February 1990 (1990-02-06)
- D5: WO 01/25881 A (ASETEK A/S; ERIKSEN, ANDRE, SLOTH; ADAMSEN, PER)  
12 April 2001 (2001-04-12)

2 INDEPENDENT CLAIM 1

2.1 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 1 is not new in the sense of Article 33(2) PCT.

Document D1 discloses (the references in parentheses applying to this document):

a cooling system for a computer system (*"heat exchange apparatus", Col.2, line 42. It is implicit for the skilled person that the apparatus of D1 is a computer system, see Col.3, line 2, "microprocessor"*), said computer system comprising

- at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit (*"microprocessor", col.3, line 2 and "heat source", Col.4 line 63 - Col. 5, line 37*) and comprising

- a reservoir having an amount of cooling liquid flowing through the reservoir (*"active spreader plate (22)", and "the fluid to circulate through the flow channels", Col.4, line 63 - Col. 5, line 37 and Col.5, line 53 - Col.7, line 3*) from an inlet to an outlet of the reservoir (*see Figure 5, the openings to from the flow channels (50) to passageways (76)*), said cooling liquid intended for accumulating and transferring thermal energy dissipated from the processing unit to the cooling liquid (*"heat transfer fluid releases heat", Col.4, line 63 - Col. 5, line 37 and Col.5, line 53 - Col.7, line 3*),

- connections being provided between the inlet of the reservoir and a heat radiator and between the outlet of the reservoir and the heat radiator for conducting the

cooling liquid from the heat radiator to the reservoir and from the reservoir to the heat radiator ("*multiple conduits (74 and 78) flowably connecting the flow channels (50) and (72) with passageways (76)*", Col.5, line 53 - Col.7, line 3 and Figure 5),

- said cooling liquid communicating with channels or segments being provided inside the reservoir ("*flow channels*", Col.4, line 63 - Col. 5, line 37 and Col.5, line 53 - Col.7, line 3) or being provided by adopting a certain shape of a heat sink with segments ("*fin array (52)*", Col.4, line 63 - Col. 5, line 37 and Col.5, line 53 - Col.7, line 3 and Fig. 5),

- the heat exchanging interface intended for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid, when the cooling liquid passes the heat exchanging interface ("*active spreader plate (20)*", Col.4, line 63 - Col. 5, line 37 and Col.5, line 53 - Col.7, line 3 and Fig. 5),

- a pumping means being provided as part of an Integrate element, said integrate element comprising the heat exchanging Interface, the reservoir and the pump ("*centrifugal pump*", Col.5, line 27 and Col.5, line 53 - Col.7, line 3 and Figure 5. *The heat exchange apparatus of D1 is an integrated system*),

- said pump intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means (*see and Col.5, line 53 - Col.7, line 3 and Fig. 5*),

- said pumping means, preferably an impeller, being mechanically integrated with a rotor of the pump and said pumping means being submerged in the cooling liquid of the reservoir ("*impeller...immersed in the heat transfer fluid*", Col. 5, lines 21-37 and Col.5, line 53 - Col.7, line 3 and Fig. 5. *Furthermore, the impeller of D1 is mechanically integrated with a rotor, Col.8, line 20, said rotor is magnetically coupled to the rotor of the fan*),

- said heat radiating means intended for radiating thermal energy from the cooling liquid, dissipated to the cooling liquid, to surroundings of the heat radiating means

*("second active spreader plate and the fan frame", Col.5, line 53 - Col.7, line 3 and Fig. 5).*

Consequently, D1 discloses all the features of claim 1.

**3 INDEPENDENT CLAIMS 12,21,33,43,63,67**

The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claims 12,21,33,43,63,67 does not involve an inventive step in the sense of Article 33(3) PCT.

The additional subject-matter of claims 12,21,33,43,63,67 relates merely to a design choice (claim 12), to practical implementation details (claims 21,33,43) or to widely used control methods (claim 63 and claim 67, e.g. see D4, Col.7, line 1 - Col.8, line 40).

**4 DEPENDENT CLAIMS 2-11,13-20,22-32,34-42,44-62,64-66,68-69**

Dependent claims 2-11,13-20,22-32,34-42,44-62,64-66,68-69 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty and/or inventive step (Article 33(2) and (3) PCT), see documents D1-D5 and pages mentioned in the Search Report.

## COOLING SYSTEM FOR A COMPUTER SYSTEM

## BACKGROUND OF THE INVENTION

- 5 The present invention relates to a cooling system for a central processing unit (CPU) or other processing unit of a computer system. More specifically, the invention relates to a liquid-cooling system for a mainstream computer system such as a PC.

During operation of a computer, the heat created inside the CPU or other processing unit  
10 must be carried away fast and efficiently, keeping the temperature within the design range specified by the manufacturer. As an example of cooling systems, various CPU cooling methods exist and the most used CPU cooling method to date has been an air-cooling arrangement, wherein a heat sink in thermal contact with the CPU transports the heat  
15 away from the CPU and as an option a fan mounted on top of the heat sink functions as an air fan for removing the heat from the heat sink by blowing air through segments of the heat sink. This air-cooling arrangement is sufficient as long as the heat produced by the CPU is kept at today's level, however it becomes less useful in future cooling arrangements when considering the development of CPUs since the speed of a CPU is said to double  
perhaps every 18 months, thus increasing the heat production accordingly.

20

Another design used today is a CPU cooling arrangement where cooling liquid is used to cool the CPU by circulating a cooling liquid inside a closed system by means of a pumping unit, and where the closed system also comprises a heat exchanger past which the cooling liquid is circulated.

25

A liquid-cooling arrangement is more efficient than an air-cooling arrangement and tends to lower the noise level of the cooling arrangement in general. However, the liquid-cooling design consists of many components, which increases the total installation time, thus making it less desirable as a mainstream solution. With a trend of producing smaller and  
30 more compact PCs for the end-users, the greater amount of components in a typical liquid-cooling arrangement is also undesirable. Furthermore, the many components having to be coupled together incurs a risk of leakage of cooling liquid from the system.

## SUMMARY OF INVENTION

It may be one object of the invention to provide a small and compact liquid-cooling solution, which is more efficient than existing air-cooling arrangements and which can be produced at a low cost enabling high production volumes. It may be another object to create a liquid-cooling arrangement, which is easy-to-use and implement, and which requires a low level of maintenance or no maintenance at all. It may be still another object of the present invention to create a liquid-cooling arrangement, which can be used with existing CPU types, and which can be used in existing computer systems. Overall, the problems which are to be solved by cooling systems relies upon obtaining a low cost of the system, a high performance of the system, high reliability of the system and high degree of fitting of the system into existing and future computer cabinets.

This object may be obtained by a cooling system for a computer system, said computer system comprising:

- at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit,
- a reservoir having an amount of cooling liquid, said cooling liquid intended for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid,
- a heat exchanging interface for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid,
- a pump being provided as part of an integrate element, said integrate element comprising the heat exchanging interface, the reservoir and the pump,
- said pump intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means,
- said heat radiating means intended for radiating thermal energy from the cooling liquid, dissipated to the cooling liquid, to surroundings of the heat radiating means.

By providing an integrate element, it is possible to limit the number of separate elements of the system. However, there is actually no need for limiting the number of elements, because often there is enough space within a cabinet of a computer system to encompass the different individual elements of the cooling system. Thus, it is surprisingly that, at all, any attempt is conducted of integrating some of the elements.

35

In preferred embodiments according to this aspect of the invention, the pump is placed inside the reservoir with at least an inlet or an outlet leading to the liquid in the reservoir. In an alternative embodiment the pump is placed outside the reservoir in the immediate vicinity of the reservoir and wherein at least an inlet or an outlet is leading directly to the



liquid in the reservoir. By placing the pump inside the reservoir or in the immediate vicinity outside the reservoir, the integrity of the combined reservoir, heat exchanger and pump is obtained, so that the element is easy to employ in new and existing computer systems, especially mainstream computer systems.

5

The object may also be obtained by a cooling system for a computer system, said computer system comprising:

- at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit,
- 10 - a reservoir having an amount of cooling liquid, said cooling liquid intended for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid,
- a heat exchanging interface for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid,
- 15 - a pump intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means,
- said cooling system being intended for thermal contact with the processing unit by means of existing fastening means associated with the processing unit, and
- said heat radiating means intended for radiating from the cooling liquid thermal energy,
- 20 dissipated to the cooling liquid, to surroundings of the heat radiating means.

The use of existing fastening means has the advantage that fitting of the cooling system is fast and easy. However, once again there is no problem for the person skilled in the art to adopt specially adapted mounting means for any element of the cooling system, because  
25 there are numerous possibilities in existing cabinets of computer systems for mounting any kind of any number of elements, also elements of a cooling system.

In preferred embodiments according to this aspect of the invention, the existing fastening means are means intended for attaching a heat sink to the processing unit, or the existing  
30 fastening means are means intended for attaching a cooling fan to the processing unit, or the existing fastening means are means intended for attaching a heat sink together with a cooling fan to the processing unit. Existing fastening means of the kind mentioned is commonly used for air cooling of CPUs of computer systems, however, air cooling arrangements being much less complex than liquid cooling systems. Nevertheless, it has  
35 ingeniously been possible to develop a complex and effective liquid cooling system capable of utilising such existing fastening means for simple and less effective air cooling arrangements.

According to an aspect of the invention, the pump is selected from the following types: Bellows pump, centrifugal pump, diaphragm pump, drum pump, flexible liner pump, flexible impeller pump, gear pump, peristaltic tubing pump, piston pump, processing cavity pump, pressure washer pump, rotary lobe pump, rotary vane pump and electro-kinetic pump. By adopting one or more of the solution of the present invention, a wide variety of pumps may be used without departing from the scope of the invention.

According to another aspect of the invention, driving means for driving the pump is selected among the following driving means: electrically operated rotary motor, piezo-electrically operated motor, permanent magnet operated motor, fluid-operated motor, capacitor-operated motor. As is the case when selecting the pump to pump the liquid, by adopting one or more of the solution of the present invention, a wide variety of pumps may be used without departing from the scope of the invention.

- 15 The object may also be obtained by a cooling system for a computer system, said computer system comprising:
- at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit,
  - a reservoir having an amount of cooling liquid, said cooling liquid intended for
  - 20 accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid,
  - a heat exchanging interface for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid,
  - a pump intended for pumping the cooling liquid into the reservoir, through the reservoir
  - 25 and from the reservoir to a heat radiating means, and
  - said cooling system further comprising a pump wherein the pump is driven by an AC electrical motor by a DC electrical power supply of the computer system,
  - where at least part of the electrical power from said power supply is intended for being converted to AC being supplied to the electrical motor.

30

It may be advantageous to use an AC motor, such as a 12V AC motor, for driving the pump in order to obtain a stabile unit perhaps having to operate 24 hours a day, 365 days a year. However, the person skilled in the art will find it unnecessary to adopt as example a 12V motor because high voltage such as 220V or 110V is readily accessible as this is the

35 electrical voltage used to power the voltage supply of the computer system itself. Although choosing to use a 12V motor for the pump, it has never been and will never be the choice of the person skilled in the art to use an AC motor. The voltage supplied by the voltage supply of the computer system itself is DC, thus this will be the type of voltage chosen by the skilled person.

In preferred embodiments according to any aspect of the invention, an electrical motor is intended both for driving the pump for pumping the liquid and for driving the a fan for establishing a flow of air in the vicinity of the reservoir, or an electrical motor is intended  
5 both for driving the pump for pumping the liquid and for driving the a fan for establishing a flow of air in the vicinity of the heat radiating means, or an electrical motor is intended both for driving the pump for pumping the liquid, and for driving the a fan for establishing a flow of air in the vicinity of the reservoir, and for driving the a fan for establishing a flow of air in the vicinity of the heat radiating means.

10

By utilising a single electrical motor for driving more than one element of the cooling system according to any of the aspects of the invention, the lesser complexity and the reliability of the cooling system will be further enhanced.

15 The heat exchanging interface may be an element being separate from the reservoir, and where the heat exchanging interface is secured to the reservoir in a manner so that the heat exchanging interface constitutes part of the reservoir when being secured to the reservoir. Alternatively, the heat exchanging interface constitutes an integrate surface of the reservoir, and where the heat exchanging surface extends along an area of the surface  
20 of the reservoir, said area of surface being intended for facing the processing unit and said area of surface being intended for the close thermal contact with the processing unit. Even alternatively, the heat exchanging interface is constitutes by a free surface of the processing unit, and where the free surface is capable of establishing heat dissipation between the processing unit and the cooling liquid through an aperture provided in the  
25 reservoir, and where the aperture extends along an area of the surface of the reservoir, said surface being intended for facing the processing unit.

The object may also be obtained by a cooling system for a computer system, said computer system comprising:

- 30 - at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit comprising
- a reservoir having an amount of cooling liquid, said cooling liquid intended for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid,
  - 35 - a heat exchanging interface for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid,
  - a pumping means being intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means,

- said heat radiating means intended for radiating thermal energy from the cooling liquid, dissipated to the cooling liquid, to surroundings of the heat radiating means,
  - said heat exchanging interface constituting a heat exchanging surface being manufactured from a material suitable for heat conducting, and
- 5 - with a first side of the heat exchanging surface facing the central processing unit being substantially plane and
- with a second side of the heat exchanging surface facing the cooling liquid being substantially plane and
  - said reservoir being manufactured from plastic, and channels or segments being
- 10 provided in the reservoir for establishing a certain flow-path for the cooling liquid through the reservoir.

Providing a plane heat exchanging surface, both the first, inner side and on the second, outer side, results in the costs for manufacturing the heat exchanging surface is reduced to

15 an absolute minimum. However, a plane first, inner surface may also result in the cooling liquid passing the heat exchanging surface too fast. This may be remedied by providing grooves along the inner surface, thereby providing a flow path in the heat exchanging surface. This however results in the costs for manufacturing the heat exchanging surface increasing.

20 The solution to this problem according to the invention has been dealt with by providing channels or segments in the reservoir housing in stead. The reservoir housing may be manufactured by injection moulding or by casting, depending on the material which the reservoir housing is made from. Providing channels or segments during moulding or casting

25 of the reservoir housing is much more cost-effective than milling grooves along the inner surface of the heat exchanging surface.

The object may also be obtained by a cooling system for a computer system, said computer system comprising:

- 30 - at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit comprising
- at least one liquid reservoir mainly for dissipating or radiating heat, said heat being accumulated and transferred by said cooling liquid,
  - said cooling system being adapted such as to provide transfer of said heat from a heat
- 35 dissipating surface to a heat radiating surface where
- said at least one liquid reservoir being provided with one aperture intended for being closed by placing said aperture covering part of, alternatively covering the whole of, the at least one processing unit in such a way that a free surface of the processing unit is in

direct heat exchanging contact with an interior of the reservoir, and thus in direct heat exchanging contact with the cooling liquid in the reservoir, through the aperture.

Heat dissipation from the processing unit to the cooling liquid must be very efficient to  
5 ensure proper cooling of the processing unit, Especially in the case, where the processing unit is a CPU, the surface for heat dissipation is limited by the surface area of the CPU. This may be remedied by utilising a heat exchanging surface being made of a material having a high thermal conductivity such as copper or aluminium and ensuring a proper thermal bondage between the heat exchanging surface and the CPU.

10 However, in a possible embodiment according to the features in the above paragraph, the heat dissipation takes place directly between the processing unit and the cooling liquid by providing an aperture in the reservoir housing, said aperture being adapted for taking up a free surface of the processing unit. Thereby, the free surface of the processing unit  
15 extends into the reservoir or constitutes a part of the boundaries of the reservoir, and the cooling liquid has direct access to the free surface of the processing unit.

According to one aspect of the invention, a method is envisaged, said method of cooling a computer system comprising at least one unit such as a central processing unit (CPU)  
20 generating thermal energy and said method utilising a cooling system for cooling the at least one processing unit and, said cooling system comprising a reservoir, at least one heat exchanging interface, an air blowing fan, a pumping means, said method of cooling comprising the steps of

- applying one of the following possibilities of how to operate the computer system:  
25 establishing, or defining, or selecting an operative status of the computer system
- controlling the operation of at least one of the following means of the computer system; the pumping means and the air blowing fan in response to at least one of the following parameters; a surface temperature of the heat generating processing unit, an internal temperature of the heat generating processing unit, or a processing load of the CPU and  
30 - in accordance with the operative status being established, defined or selected, controlling the operation of the computer system in order to achieve at least one of the following conditions; a certain cooling performance of the cooling system, a certain electrical consumption of the cooling system, a certain noise level of the cooling system.

35 Applying the above method ensures an operation of the computer system being in accordance with selected properties during the use of the computer system. For some applications, the cooling performance is vital such as may be the case when working with image files or when downloading large files from a network during which the processing units is highly loaded and thus generating much heat. For other applications, the electrical

power consumption is more vital such as may be the case when utilising domestic computer systems or in large office building in environments where the electrical grid may be weak such as in third countries. In still other applications, the noise generated by the cooling system is to be reduced to a certain level, which may be the case in office buildings  
5 with white collar people working alone, or at home, if the domestic computer perhaps is situated in the living room, or at any other location where other exterior considerations have to be dealt with.

According to another aspect of the invention, a method is envisaged, said method being  
10 employed with cooling system further comprising a pumping means with an impeller for pumping the cooling liquid through a pumping housing, said pumping means being driven by an AC electrical motor with a stator and a rotor, and said pumping means being provided with a means for sensing a position of the rotor, and wherein the method comprises the following steps:

- 15 - initially establishing a preferred rotational direction of the rotor of the electrical motor
- before start of the electrical motor, sensing the angular position of the rotor
- during start, applying an electrical AC voltage to the electrical motor and selecting the signal value, positive or negative, of the AC voltage at start of the electrical motor
- said selection being made according to the preferred rotational direction, and
- 20 - said application of the AC voltage being performed by the computer system for applying the AC voltage from the electrical power supply of the computer system during conversions of the electrical DC voltage of the power supply to AC voltage for the electrical motor.

Adopting the above method according to the invention ensures the most efficient  
25 circulation of cooling liquid in the cooling system and at the same time ensures the lowest possible energy consumption of the electrical motor driving the impeller. The efficient circulation of the cooling liquid is obtained by means of an impeller being designed for rotation in one rotational direction only, thus optimising the impeller design with regard to the only one rotational direction as opposed to both rotational directions. The low  
30 energy consumption is achieved because of the impeller design being optimised, thus limiting the necessary rotational speed of the impeller for obtaining a certain amount of flow of the cooling liquid through the cooling system. A bonus effect of the lowest possible energy consumption being obtained is the lowest possible noise level of the pump also being obtained. The noise level of the pump is amongst other parameters also dependent  
35 on the design and the rotational speed of the impeller. Thus, an optimised impeller design and impeller speed will reduce the noise level to the lowest possible in consideration of ensuring a certain cooling capacity.

BRIEF DESCRIPTION OF THE FIGURES

The invention will hereafter be described with reference to the drawings, where

- Fig. 1 shows an embodiment of the prior art. The figure shows the typical components in  
5 an air-cooling type CPU cooling arrangement.
- Fig. 2 shows an embodiment of the prior art. The figure shows the parts of the typical air-cooling type CPU cooling arrangement of figure 1 when assembled.
- Fig. 3 shows an embodiment of the prior art. The figure shows the typical components in a liquid-cooling type CPU cooling arrangement.
- 10 Fig. 4 is an exploded view of the invention and the surrounding elements.
- Fig. 5 shows the parts shown in the previous figure when assembled and attached to the motherboard of a computer system.
- Fig. 6 is an exploded view of the reservoir from the previous figures 4 and 5 seen from the opposite site and also showing the pump.
- 15 Fig. 7 is a cut-out view into the reservoir housing the pump and an inlet and an outlet extending out of the reservoir.
- Fig. 8 is a view of the cooling system showing the reservoir connected to the heat radiator.
- Fig. 9-10 are perspective views of a possible embodiment of reservoir housing providing direct contact between a CPU and a cooling liquid in a reservoir.
- 20 Fig. 11-13 are perspective views of a possible embodiment of heat sink and a reservoir housing constituting an integrated unit.
- Fig. 14 is a perspective view of the embodiment shown in fig. 9-10 and the embodiment shown in fig. 11-13 all together constituting an integrated unit.
- Fig. 15-16 are perspective view of a preferred embodiment of a reservoir and a pump and  
25 a heat exchanging surface constituting an integrated unit.

#### DETAILED DESCRIPTION OF THE INVENTION

- Fig. 1 is an exploded view of an embodiment of prior art cooling apparatus for a computer  
30 system. The figure shows the typical components in an air-cooling type CPU cooling arrangement. The figure shows a prior art heat sink 4 intended for air cooling and provided with segments intersected by interstices, a prior art air fan 5 which is to be mounted on top of the heat sink by use of fastening means 3 and 6.
- 35 The fastening means comprises a frame 3 provided with holes intended for bolts, screws, rivets or other suitable fastening means (not shown) for thereby attaching the frame to a motherboard 2 of a CPU 1 or onto another processing unit of the computer system. The frame 3 is also provided with mortises provided in perpendicular extending studs in each corner of the frame, said mortises intended for taking up tenons of a couple of braces. The

braces 6 are intended for enclosing the heat sink 4 and the air fan 5 so that the air fan and the heat sink thereby is secured to the frame. Using proper retention mechanisms, when the frame is attached to the motherboard of the CPU of other processing unit, and when the tenons of the braces are inserted into the mortises of the frame, the air fan and heat exchanger is pressed towards the CPU by using a force perpendicular to the CPU surface, said force being provided by lever arms.

Fig. 2 shows the parts of the typical air-cooling type CPU cooling arrangement of figure 1, when assembled. The parts are attached to each other and will be mounted on top of a CPU on a motherboard (not shown) of a computer system.

Fig. 3 shows another embodiment of a prior art cooling system. The figure shows the typical components in a liquid-cooling type CPU cooling arrangement. The figure shows a prior art heat exchanger 7, which is in connection with a prior art liquid reservoir 8, a prior art liquid pump 9 and a heat radiator 11 and an air fan 10 provided together with the heat radiator. The prior art heat exchanger 7, which can be mounted on a CPU (not shown) is connected to a radiator and reservoir, respectively. The reservoir serves as a storage unit for excess liquid not capable of being contained in the remaining components. The reservoir is also intended as a means for venting the system of any air entrapped in the system and as a means for filling the system with liquid. The heat radiator 11 serves as a means for removing the heat from the liquid by means of the air fan 10 blowing air through the heat radiator. All the components are in connection with each other via tubes for conducting the liquid serving as the cooling medium.

Fig. 4 is an exploded view of a cooling system according to an embodiment of the invention. Also elements not being part of the cooling system as such are shown. The figure shows a central processing unit CPU 1 mounted on a motherboard of a computer system 2. The figure also shows a part of the existing fastening means, i.e. amongst others the frame 3 with mortises provided in the perpendicular extending studs in each corner of the frame. The existing fastening means, i.e. the frame 3 and the braces 6, will during use be attached to the motherboard 2 by means of bolts, screws, rivets or other suitable fastening means extending through the four holes provided in each corner of the frame and extending through corresponding holes in the motherboard of the CPU. The frame 3 will still provide an opening for the CPU to enable the CPU to extend through the frame.

The heat exchanging interface 4 is a separate element and is made of a heat conducting material having a relative high heat thermal conductivity such as copper or aluminium, and which will be in thermal contact with the CPU 1, when the cooling system is fastened to the



motherboard 2 of the CPU. The heat exchanging surface constitutes part of a liquid reservoir housing 14, thus the heat exchanger 4 constitutes the part of the liquid reservoir housing facing the CPU. The reservoir may as example be made of plastic or of metal. The reservoir or any other parts of the cooling system, which are possibly manufactured from a plastic material may be "metallised" in order to minimise liquid diffusion or evaporation of the liquid. The metal may be provided as a thin layer of metal coating provided on either or on both of the internal side or the external side of the plastic part.

If the reservoir is made of metal or any other material having a relative high heat conductivity compared to as example plastic, the heat exchanging interface as a separate element may be excluded because the reservoir itself may constitute a heat exchanger over an area, wherein the reservoir is in thermal contact with the processing unit. Alternatively to having the heat exchanging interface constitute part of the liquid reservoir housing, the liquid reservoir housing may be tightly attached to the heat exchanging interface by means of screws, glue, soldering, brazing or the like means for securing the heat exchanging interface to the housing and vice versa, perhaps with a sealant 5 provided between the housing and the heat exchanging interface.

Alternatively to providing a heat exchanging interface integrate with the reservoir containing the cooling liquid, it will be possible to exclude the heat exchanger and providing another means for dissipating heat from the processing unit to the cooling liquid in the reservoir, The other means will be a hole provided in the reservoir, said hole intended for being directed towards the processing unit. Boundaries of the hole will be sealed towards boundaries of the processing unit or will be sealed on top of the processing unit for thereby preventing cooling liquid from the reservoir from leaking. The only prerequisite to the sealing is that a liquid-tight connection is provided between boundaries of the hole and the processing unit or surrounding of the processing unit, such as a carrier card of the processing unit.

By excluding the heat exchanger, a more effective heat dissipation will be provided from the processing unit and to the cooling liquid of the reservoir, because the intermediate element of a heat exchanger is eliminated. The only obstacle in this sense is the provision of a sealing being fluid-tight in so that the cooling liquid in the reservoir is prevented from leaking.

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The heat exchanging surface 4 is normally a copper plate. When excluding the heat exchanging surface 4, which may be a possibility not only for the embodiments shown in fig. 4, but for all the embodiments of the invention, it may be necessary to provide the CPU with a resistant surface that will prevent evaporation of the cooling liquid and/or any

damaging effect that the cooling liquid may pose to the CPU. A resistant surface may be provided the CPU from the CPU producer or it may be applied afterwards. A resistant surface to be applied afterwards may e.g. be a layer, such as an adhesive tape provided on the CPU. The adhesive tape may be made with a thin metal layer e.g. in order to prevent  
5 evaporation of the cooling liquid and/or any degeneration of the CPU itself.

Within the liquid reservoir, a liquid pump (not shown) is placed for pumping a cooling liquid from an inlet tube 15 connection being attached to the housing of the reservoir through the reservoir and past the heat exchanger in thermal contact with the CPU to an  
10 outlet tube connection 16 also being attached to the reservoir housing. The existing fastening means comprising braces 6 with four tenons and the frame 3 with four corresponding mortises will fasten the reservoir and the heat exchanger to the motherboard of the CPU. When fastening the two parts of the existing fastening means to each other the fastening will by means of the lever arms 18 create a force to assure  
15 thermal contact between the CPU 1 mounted on the motherboard and the heat exchanger 4 being provided facing the CPU.

The cooling liquid of the cooling system may be any type of cooling liquid such as water, water with additives such as anti-fungicide, water with additives for improving heat  
20 conducting or other special compositions of cooling liquids such as electrically non-conductive liquids or liquids with lubricant additives or anti-corrosive additives.

Fig. 5 shows the parts shown in fig. 4 when assembled and attached to the motherboard of a CPU of a computer system 2. The heat exchanger and the CPU is in close thermal contact  
25 with each other. The heat exchanger and the remainder of the reservoir 14 is fastened to the motherboard 2 by means of the existing fastening means being secured to the motherboard of the CPU and by means of the force established by the lever arms 18 of the existing fastening means. The tube inlet connection 15 and the tube outlet connection 16 are situated so as to enable connection of tubes to the connections.

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Fig. 6 is an exploded view of the reservoir shown in previous fig. 4 and fig. 5 and seen from the opposite site and also showing the pump 21 being situated inside the reservoir. Eight screws 22 are provided for attaching the heat exchanging surface 4 to the remainder of the reservoir. The heat exchanging surface is preferably made from a copper plate  
35 having a plane outer surface as shown in the figure, said outer surface being intended for abutting the free surface of the heat generating component such as the CPU (see fig. 4). However, also the inner surface (not shown, see fig. 7) facing the reservoir is plane. Accordingly, the copper plate need no machining other than the shaping of the outer boundaries into the octagonal shape used in the embodiment shown and drilling of holes

for insertion of the bolts. No milling of the inner and/or the outer surface need be provided.

A sealant in form of a gasket 13 is used for the connection between the reservoir 14 and the heat exchanging surface forming a liquid tight connection. The pump is intended for being placed within the reservoir. The pump has a pump inlet 20 through which the cooling liquid flows from the reservoir and into the pump, and the pump has a pump outlet 19 through which the cooling liquid is pumped from the pump and to the outlet connection. The figure also shows a lid 17 for the reservoir. The non-smooth inner walls of the reservoir and the fact that the pump is situated inside the reservoir will provide a swirling of the cooling liquid inside the reservoir.

However, apart from the non-smooth walls of the reservoir and the pump being situated inside the reservoir, the reservoir may be provided with channels or segments for establishing a certain flow-path for the cooling liquid through the reservoir (see fig 9-10 and fig 15). Channel or segments are especially needed when the inner surface of the heat exchanging surface is plane and/or when the inner walls of the reservoir are smooth and/or if the pump is not situated inside the reservoir. In either of the circumstances mentioned, the flow of the cooling liquid inside the reservoir may result in the cooling liquid passing the reservoir too quickly and not being resident in the reservoir for a sufficient amount of time to take up a sufficient amount of heat from the heat exchanging surface. By providing channels or segments inside the reservoir, a flow will be provided forcing the cooling liquid to pass the heat exchanging surface, and the amount of time increased of the cooling liquid being resident inside the reservoir, thus enhancing heat dissipation. If channels or segments are to be provided inside the reservoir, the shape and of the channels and segments may be decisive of whether the reservoir is to be made of plastic, perhaps by injection moulding, or is to be made of metal such as aluminium, perhaps by die casting.

The cooling liquid enters the reservoir through the tube inlet connection 15 and enters the pump inlet 20, and is pumped out of the pump outlet 19 connected to the outlet connection 16. The connection between the reservoir and the inlet tube connection and the outlet tube connection, respectively, are made liquid tight. The pump may not only be a self-contained pumping device, but may be made integrated into the reservoir, thus making the reservoir and a pumping device one single integrated component. This single integrated element of the reservoir and the pumping device may also be integrated, thus making the reservoir, the pumping device and the heat exchanging surface one single integrated unit. This may as example be possible if the reservoir is made of a metal such as aluminium. Thus, the choice of material provides the possibility of constituting both the

reservoir and a heat exchanging surface having a relatively high heat conductivity, and possibly also renders the possibility of providing bearings and the like constructional elements for a motor and a pumping wheel being part of the pumping device.

- 5 In an alternative embodiment, the pump is placed in immediate vicinity of the reservoir, however outside the reservoir. By placing the pump outside, but in immediate vicinity of the reservoir, still an integrate element may be obtained, The pump or the inlet or the outlet is preferably positioned so as to obtain a turbulence of flow in the immediate vicinity of the heat exchanging interface, thereby promoting increased heat dissipation between
- 10 the heat exchanging interface and the cooling liquid. even in the alternative, a pumping member such as an impeller (see fig. 15-16) may be provided in the immediate vicinity of the heat exchanging surface. The pumping member itself normally introduces a turbulence of flow, and thereby the increased heat dissipation is promoted irrespective of the position of the pump itself, or the position of the inlet or of the outlet to the reservoir or to the
- 15 pump.

- The pump may be driven by an AC or a DC electrical motor. When driven by an AC electrical motor, although being technically and electrically unnecessary in a computer system, this may be accomplished by converting part of the DC electrical power of the
- 20 power supply of the computer system to AC electrical power for the pump. The pump may be driven by an electrical motor at any voltage common in public electrical networks such as 110V or 220V. However, in the embodiment shown, the pump is driven by a 12V AC electrical motor.

- 25 Control of the pump in case the pump is driven by an AC electrical motor, preferably takes place by means of the operative system or an alike means of the computer system itself, and where the computer system comprises means for measuring the CPU load and/or the CPU temperature. Using the measurement performed by the operative system or alike system of the computer system eliminates the need for special means for operating the
- 30 pump. Communication between the operative system or alike system and a processor for operating the pump may take place along already established communication links in the computer system such as a USB-link. Thereby, a real-time communication between the cooling system and the operative system is provided without any special means for establishing the communication.

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In the case of the motor driving the pump is an AC electrical motor, the above method of controlling the pump may be combined with a method, where said pumping means is provided with a means for sensing a position of the rotor of the electrical motor, and wherein the following steps are employed: Initially establishing a preferred rotational

direction of the rotor of the electrical motor, before start of the electrical motor, sensing the angular position of the rotor, during start, applying an electrical AC voltage to the electrical motor and selecting the signal value, positive or negative, of the AC voltage at start of the electrical motor, said selection being made according to the preferred  
5 rotational direction, and said application of the AC voltage being performed by the computer system for applying the AC voltage from the electrical power supply of the computer system during conversion of the electrical DC voltage of the power supply to AC voltage for the electrical motor. By the operative system of the computer system itself generating the AC voltage for the electrical motor, the rotational direction of the pump is  
10 exclusively selected by the computer system, non-depending on the applied voltage of the public grid powering the computer system.

Further control strategies utilising the operative system or alike system of the computer system may involve balancing the rotational speed of the pump as a function of the cooling  
15 capacity needed. If a lower cooling capacity is needed, the rotational speed of the pump, may be limited, thereby limiting the noise generating by the motor driving the pump.

In the case an air fan is provided in combination with a heat sink as shown in fig. 1, of the air fan is provided in combination with the heat radiator, the operative system or alike  
20 system of the computer system may be designed for regulating the rotational speed of the pump, and thus of the motor driving the pump, and the rotational speed of the air fan, and thus the motor driving the air fan. The regulation will take into account the cooling capacity needed, but the regulation will at the same time take into account which of the  
25 two cooling means, i.e. the pump and the air fan, is generating the most noise. Thus, it the air fan generally is generating more noise than the pump, then the regulation will reduce the rotational speed of the air fan before reducing the rotational speed of the pump, whenever a lower cooling capacity is needed. Thereby, the noise level of the entire cooling system is lowered as much as possible. If the opposite is the case, i.e. the pump generally generating more noise than the air fan, then the rotational speed of the pump  
30 will be reduced before reducing the rotational speed of the air fan.

Even further control strategies involve controlling the cooling capacity in dependence on the type of computer processing taking place. Some kind of computer processing, such as word-processing, applies a smaller load on the processing units such as the CPU than other  
35 kinds of computer processing, such as image processing. Therefore, the kind of processing taking place on the computer system may be used as an indicator of the cooling capacity. It may even be possible as part of the operative system or similar system to establish certain cooling scenarios, depending on the kind of processing intended by the user. If the user selects as example word-processing, a certain cooling strategy is applied based on a

limited need for cooling. If the user selects as example Image-processing, a certain cooling strategy is applied based on an increased need for cooling. Two or more different cooling scenarios may be established depending on the capacity and the control possibilities and capabilities of the cooling system and depending on the intended use of the computer system, either as selected by a user during use of the computer system or as selected when choosing hardware during build-up of the computer system, i.e. before actual use of the computer system.

The pump is not being restricted to a mechanical device, but can be in any form capable of pumping the cooling liquid through the system. However, the pump is preferably one of the following types of mechanical pumps: Bellows pump, centrifugal pump, diaphragm pump, drum pump, flexible liner pump, flexible impeller pump, gear pump, peristaltic tubing pump, piston pump, processing cavity pump, pressure washer pump, rotary lobe pump, rotary vane pump and electro-kinetic pump. Similarly, the motor driving the pumping member need not be electrical but may also be a piezo-electrically operated motor, a permanent magnet operated motor, a fluid-operated motor or a capacitor-operated motor. The choice of pump and the choice of motor driving the pump is dependent on many different parameters, and it is up to the person skilled in the art to choose the type of pump and the type of motor depending on the specific application. As example, some pumps and some motors are better suited for small computer systems such as lab-tops, some pumps and some motors are better suited for establishing a high flow of the cooling liquid and thus a high cooling effect, and even some pumps and motors are better suited for ensuring a low-noise operation of the cooling system.

Fig. 7 is a cut-out view into the reservoir, when the reservoir and the heat exchanging surface 4 is assembled and the pump 21 is situated inside the reservoir. The reservoir is provided with the tube inlet connection (not seen from the figure) through which the cooling liquid enters the reservoir. Subsequently, the cooling liquid flows through the reservoir passing the heat exchanging surface and enters the inlet of the pump. After having been passed through the pump, the cooling liquid is passed out of the outlet of the pump and further out through the tube outlet connection 16. The figure also shows a lid 17 for the reservoir. The flow of the cooling liquid inside the reservoir and through the pump may be further optimised in order to use as little energy as possible for pumping the cooling liquid, but still having a sufficient amount of heat from the heat exchanging surface being dissipated in the cooling liquid. This further optimisation can be established by changing the length and shape of the tube connection inlet within the reservoir, and/or by changing the position of the pump inlet, and/or for instance by having the pumping device placed in the vicinity and in immediate thermal contact with the heat exchanging surface and/or by providing channels or segments inside the reservoir.

In this case, an increased turbulence created by the pumping device is used to improve the exchange of heat between the heat exchanging surface and the cooling liquid. Another or an additional way of improving the heat exchange is to force the cooling liquid to pass  
5 through specially adapted channels or segments being provided inside the reservoir or by making the surface of the heat exchanging surface plate inside the reservoir uneven or by adopting a certain shape of a heat sink with segments. In the figure shown, the inner surface of the heat exchanging surface facing the reservoir is plane.

10 Fig. 8 is a perspective view of the cooling system showing the reservoir 14 with the heat exchanging surface (not shown) and the pump (not shown) inside the reservoir. The tube inlet connection and the tube outlet connection are connected to a heat radiator by means of connecting tubes 24 and 25 through which the cooling liquid flows into and out of the reservoir and the heat radiator, respectively. Within the heat radiator 11, the cooling liquid  
15 passes a number of channels for radiating the heat, which has been dissipated into the cooling liquid inside the reservoir, and to the surroundings of the heat exchanger. The air fan 10 blows air past the channels of the heat radiator in order to cool the radiator and thereby cooling the cooling liquid flowing inside the channels through the heat radiator and back into the reservoir.

20 According to the invention, the heat radiator 11 may be provided alternatively. The alternative heat radiator is constituted by a heat sink, such as a standard heat sink made of extruded aluminium with fins on a first side and a substantially plane second side. An air-fan may be provided in connection with the fins along the first side. Along the second  
25 side of the heat sink a reservoir is provided with at least one aperture intended for being closed by placing said aperture covering part of, alternatively covering the whole of, the substantial plane side of the heat sink. When closing the reservoir in such a way a surface of the heat sink is in direct heat exchanging contact with an interior of the reservoir, and thus in direct heat exchanging contact with the cooling liquid in the reservoir, through the  
30 at least one aperture. This alternative way of providing the heat radiator may be used in the embodiment shown in fig. 8 or may be used as a heat radiator for another use and/or for another embodiment of the invention.

A pumping means for pumping the cooling liquid through the reservoir may or may not be  
35 provided inside the reservoir at the heat sink. The reservoir may be provided with channels or segments for establishing a certain flow-path for the cooling liquid through the reservoir. Channels or segments are especially needed when the inner surface of the heat exchanging surface is plane and/or when the inner walls of the reservoir are smooth and/or if the pump is not situated inside the reservoir. In either of the circumstances

mentioned, the flow of the cooling liquid inside the reservoir may result in the cooling liquid passing the reservoir too quickly and not being resident in the reservoir for a sufficient amount of time to take up a sufficient amount of heat from the heat exchanging surface. If channels or segments in the reservoir are to be provided inside the reservoir, the shape and of the channels and segments may be decisive of whether the reservoir is to be made of plastic, perhaps by injection moulding, or is to be made of metal such as aluminium, perhaps by die casting.

By means of the alternative heat radiator, the heat radiator 11 is not provided as is shown in the figure with the rather expensive structure of channels leading the cooling liquid along ribs connecting the channels for improved surface of the structure. Instead, the heat radiator is provided as described as a unit constituted by a heat sink with or without a fan and a reservoir, and thereby providing a simpler and thereby cheaper heat radiator than the heat radiator 11 shown in the figure.

The alternative heat radiator provided as an unit constituted by a heat sink and a reservoir, may be used solely, with or without a pump inside the reservoir and with or without the segments or channels, for being placed in direct or indirect thermal contact with a heat generating processing unit such as CPU or with the heat exchanging surface, respectively. These embodiments of the invention may e.g. be used for a reservoir, where the cooling liquid along a first side within the reservoir is in direct heat exchanging contact with the heat generating processing unit such as a CPU and the cooling liquid along a second side within the reservoir is in direct heat exchanging contact with a heat sink. Such a reservoir may be formed such as to provide a larger area of heat exchanging surface towards the heat generating processing unit such as a CPU than the area of the heat exchanging surface facing the heat sink. This may e.g. have the purpose of enlarging the area of the heat exchanging surface so as to achieve an improved heat dissipation form e.g. the CPU to the heat sink than that of a conventional heat sink without a reservoir attached. Conventional heat sinks normally only exchanges heat with the CPU through the area as given by the area of the top side of the CPU. A system comprising a liquid reservoir and a heat sink with a fan provided has been found to be a simple, cost optimised system with an improved heat dissipation than that of a standard heat sink with a fan, but without the reservoir. In another embodiment of the invention, which may be derived from fig. 8, the air fan and the heat radiator is placed directly in alignment of the reservoir. Thereby, the reservoir 14, the air fan 10 and the radiator 11 constitute an integrate unit. Such an embodiment may provide the possibility of omitting the connection tubes, and passing the cooling liquid directly from the heat radiator to the reservoir via an inlet connection of the reservoir, and directly from the reservoir to the heat radiator via an outlet connection of the reservoir. Such an embodiment may even render the possibility of



both the pumping device of the liquid pump inside the reservoir and the electrical motor for the propeller of the air fan 23 of the heat radiator 11 being driven by the same electrical motor, thus making this electrical motor the only motor of the cooling system.

- 5 When placing the heat radiator on top of the air fan now placed directly in alignment with the reservoir and connecting the heat radiator directly to the inlet connection and outlet connection of the reservoir, a need for tubes will not be present. However, if the heat radiator and the reservoir is not in direct alignment with each other, but tubes may still be needed, but rather than tubes, pipes made of metal such as copper or aluminium may be
- 10 employed, such pipes being impervious to any possible evaporation of cooling liquid: Also, the connections between such pipes and the heat radiator and the reservoir, respectively, may be soldered so that even the connections are made impervious to evaporation of cooling liquid.
- 15 In the derived embodiment just described, an integrated unit of the reservoir, the heat exchanging surface and the pumping device will be given a structure establishing improved heat radiating characteristics because the flow of air of the air fan may also be directed along outer surfaces of the reservoir. If the reservoir is made of a metal, the metal will be cooled by the air passing the reservoir after having passed or before passing the heat
- 20 radiator. If the reservoir is made of metal, and if the reservoir is provided with segments on the outside surface of the reservoir, such cooling of the reservoir by the air will be further improved. Thereby, the integrated unit just described will be applied improved heat radiating characteristics, the heat radiation function normally carried out by the heat radiator thus being supplemented by one or more of the further elements of the cooling
- 25 system, i.e. the reservoir, the heat exchanging surface, the liquid pump and the air fan.

Fig. 9-10 show an embodiment of a reservoir housing 14, where channels 25 are provided inside the reservoir for establishing a forced flow of the cooling liquid inside the reservoir. The channels 25 in the reservoir 14 lead from an inlet 15 to an outlet 16 like a maze

30 between the inlet and the outlet. The reservoir 14 is provided with an aperture 27 having outer dimensions corresponding to the dimensions of a free surface of the processing unit 1 to be cooled. In the embodiment shown, the processing unit to be cooled is a CPU 1:

When channels 26 are provided inside the reservoir, the shape of the channels may be

35 decisive of whether the reservoir is to be made of plastic, perhaps manufactured by injection moulding, or is to be made of metal such as aluminium, perhaps manufactured by extrusion or by die casting.

The reservoir 14 or any other parts of the cooling system, which are possibly manufactured from a plastic material may be "metallised" in order to minimise liquid diffusion or evaporation of the liquid. The metal may be provided as a thin layer of metal coating provided on either or on both of the internal side or the external side of the plastic part.

The CPU 1 is intended for being positioned in the aperture 27, as shown in fig. 10, so that outer boundaries of the CPU are engaging boundaries of the aperture. Possibly, a sealant (not shown) may be provided along the boundaries of the CPU and the aperture for ensuring a fluid tight engagement between the boundaries of the CPU and the boundaries of the aperture. When the CPU 1 is positioned in the aperture 27, the free surface (not shown) of the CPU is facing the reservoir, i.e. the part of the reservoir having the channels provided. Thus, when positioned in the aperture 27 (see fig. 10), the free surface of the CPU 1 is having direct contact with cooling liquid flowing through the channels 26 in the reservoir.

When cooling liquid is forced from the inlet 15 along the channels 26 to the outlet 16, the whole of the free surface of the CPU 1 will be passed over by the cooling liquid, thus ensuring a proper and maximised cooling of the CPU. The configuration of the channels may be designed and selected according to any one or more provisions, i.e. high heat dissipation, certain flow characteristics, ease of manufacturing etc. Accordingly, the channels may have another design depending on any desire or requirement and depending on the type of CPU and the size and shape of the free surface of the CPU. Also, other processing units than a CPU may exhibit different needs for heat dissipation, and may exhibit other sizes and shapes of the free surface, leading to a need for other configurations of the channels. If the processing unit is very elongate, such as a row of microprocessors, one or a plurality of parallel channels may be provided, perhaps just having a common inlet and a common outlet.

Fig. 11-13 show an embodiment of a heat sink 4, where segments 28 are provided at a first side 4A of the heat sink, and fins 29 for dissipating heat to the surroundings are provided at the other, second side 4B of the heat sink. An intermediate reservoir housing 30 is provided having a recessed reservoir at the one side facing the first side 4A of the heat sink. The recessed reservoir 30 has an inlet 31 and an outlet 32 at the other side opposite the side facing the heat sink 4.

When segments 28 are provided on the first side 4A of the heat sink, the shape of the segments may be decisive of whether the reservoir, which is made from metal such as aluminium or copper, is to be made by extrusion or is to be made by other manufacturing

processes such as die casting. Especially when the segments 28 are linear and are parallel with the fins 29, as shown in the embodiment, extrusion is a possible and cost-effective means of manufacturing the heat sink 4.

- 5 The Intermediate reservoir 30 or any other parts of the cooling system, which are possibly manufactured from a plastic material may be "metallised" in order to minimise liquid diffusion or evaporation of the liquid. The metal may be provided as a thin layer of metal coating provided on either or on both of the internal side or the external side of the plastic part.

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The recessed reservoir is provided with a kind of serration 33 along opposite sides of the reservoir, and the inlet 31 and the outlet 32, respectively, are provided at opposite corners of the intermediate reservoir 30. The segments 28 provided at the first side 4A of the heat sink, i.e. the side facing the intermediate reservoir 30, are placed so that when the heat  
15 sink is assembled with the intermediate reservoir housing (see fig 13) the segments 29 run from one serrated side of the reservoir to the other serrated side of the reservoir.

- When cooling liquid is forced from the inlet 31 through the reservoir, along channels (not shown) formed by the segments 29 of the heat sink 4 and to the outlet 32, the whole of  
20 the first side 4A of the heat sink will be passed over by the cooling liquid, thus ensuring a proper and maximised heat dissipation between the cooling liquid and the heat sink. The configuration of the segments on the first side 4A of the heat sink and the configuration of the serrated sides of the intermediate reservoir housing may be designed and selected according to any provisions. Accordingly, the segments may have another design, perhaps  
25 being wave-shaped or also a serrated shape, depending on any desired flow characteristics of the cooling liquid and depending on the type of heat sink and the size and shape of the reservoir.

- Also other types of heat sinks, perhaps circular shaped heat sinks may exhibit different  
30 needs for heat dissipation, may exhibit other sizes and shapes of the free surface, leading to a need for other configurations of the segments and the intermediate reservoir. If the heat sink and the reservoir are circular or oval, a spiral-shaped segmentation or radially extending segments may be provided, perhaps having the inlet or the outlet in the centre of the reservoir. If an impeller of the pump is provided, as shown in fig. 15-16, the  
35 impeller of the pump may be positioned in the centre of a spiral-shaped segmentation or in the centre of radially extending segments.

Fig. 14 shows the reservoir 14 shown in fig. 9-10 and the heat sink 4 and the intermediate reservoir 30 shown in fig. 11-13 being assembled for thereby constituting an integrated

monolithic unit. It is not absolutely necessary to assemble the reservoir 14 of fig. 9-10 and the heat sink 4 and the intermediate reservoir 30 of fig. 11-13 in order to obtain a properly functioning cooling system. The inlet 15 and the outlet 16 of the reservoir 14 of fig. 9-10 may be connected to the outlet 32 and the inlet 31, respectively, of the intermediate  
5 reservoir of fig. 11-13 by means of tubes or pipes.

The reservoir 14 of fig. 9-10 and the heat sink 4 and the intermediate reservoir 30 of fig. 11-13 may then be positioned in the computer system at different locations. However, by assembling the reservoir 14 of fig. 9-10 and the heat sink 4 and the intermediate reservoir  
10 30 of fig. 11-13 a very compact monolithic unit is obtained, also obviating the need for tubes or pipes. Tubes or pipes may involve an increased risk of leakage of cooling liquid or may require soldering or other special working in order to eliminate the risk of leakage of cooling liquid. By eliminating the need for tubes or pipes, any leakage and any additional working is obviated when assembling the cooling system.

15 Fig. 15-16 show a possible embodiment of a reservoir according to the invention. The reservoir is basically similar to the reservoir shown in fig. 9-10. However, an impeller 33 of the pump of the cooling system is provided in direct communication with the channels 26. Also, in the embodiment shown, a heat exchanging interface 4 such as a surface made  
20 from a copper plate, alternatively a plate of another material having a high thermal conductivity, is placed between the channels 26 inside the reservoir and the CPU 1 as the processing unit.

The heat exchanging surface 4 is preferably made from a copper plate having a plane  
25 outer surface as shown in the figure, said outer surface being intended for abutting the free surface of the heat generating component such as the CPU 1 (see fig. 4). However, also the inner surface (not shown, see fig. 7) facing the reservoir is plane. Accordingly, the copper plate need no machining other than the shaping of the outer boundaries into the specially adapted shape used in the embodiment shown and drilling of holes for insertion  
30 of the bolts. No milling of the inner and/or the outer surface need be provided.

The provision of the heat exchanging surface 4 need not be a preferred embodiment, seeing that the solution incorporating the aperture (see fig. 9-10) result in a direct heat exchange between the free surface of the CPU or other processing unit and the cooling  
35 liquid flowing along the channels in the reservoir. However, the heat exchanging surface enables usage of the cooling system independently on the type and size of the free surface of CPU or other processing unit.

In the embodiment shown, the heat exchanging surface 4 is secured to the reservoir by means of bolts 22. Other convenient fastening means may be used. The heat exchanging surface 4 and thus the reservoir 14 may be fastened to the CPU 1 or other processing unit by any suitable means such as soldering, brazing or by means of thermal paste combined with glue. Alternatively, special means (not shown) may be provided for ensuring a thermal contact between the free surface of the CPU or other processing unit and the heat exchanging surface. One such means may be the fastening means shown in fig. 4 and fig. 5 or similar fastening means already provided as part of the computer system.

- 10 When channels 26 are provided inside the reservoir 14, the shape of the channels may be decisive of whether the reservoir is to be made of plastic, perhaps by injection moulding, or is to be made of metal such as aluminium, perhaps by die casting.

- The reservoir 14 or any other parts of the cooling system, which are possibly manufactured from a plastic material may be "metallised" in order to minimise liquid diffusion or evaporation of the liquid. The metal may be provided as a thin layer of metal coating provided on either or on both of the internal side or the external side of the plastic part.

- 20 The impeller 33 (see fig. 14) of the pump is positioned in a separate recess of the channels 26, said separate recess having a size corresponding to the diameter of the impeller of the pump. The recess is provided with an inlet 34 and an outlet 35 being positioned opposite an inlet 31 and an outlet 32 of cooling liquid to and from, respectively, the channels 26. The impeller 33 of the pump has a shape and a design intended only for one way rotation, 25 In the embodiment shown a clock-wise rotation only. Thereby, the efficiency of the impeller of the pump is highly increased compared to impellers capable of and intended for both clock-wise and counter clock-wise rotation.

- The increased efficiency of the impeller design results in the electric motor (not shown) driving the impeller of the pump possibly being smaller than otherwise needed for establishing a proper and sufficient flow of cooling liquid through the channels. In a preferred embodiment, the electric motor is an AC motor, preferably a 12V AC motor, leading to the possibility of an even smaller motor needed for establishing the proper and sufficient flow of cooling liquid through the channels.

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The impeller of the pump may be driven by an AC or a DC electrical motor. However, as mentioned, preferably the impeller of the pump is driven by an AC electrical motor. Although being technically and electrically unnecessary to use an AC electrical motor in a computer system, this may be accomplished by converting part of the DC electrical power

of the power supply of the computer system to AC electrical power for the impeller of the pump. The impeller may be driven by an electrical motor at any voltage common in public electrical networks such as 110V or 220V. However, in the embodiment shown, the impeller of the pump is driven by a 12V electrical motor.

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The invention has been described with reference to specific embodiments and with reference to specific utilisation, it is to be noted that the different embodiments of the invention may be manufactured, marketed, sold and used separately or jointly in any combination of the plurality of embodiments. In the above detailed description of the  
10 invention, the description of one embodiment, perhaps with reference to one or more figures, may be incorporated into the description of another embodiment, perhaps with reference to another or more other figures, and vice versa. Accordingly, any separate embodiment described in the text and/or in the drawings, or any combination of two or more embodiments is envisaged by the present application.

## CLAIMS

1. A cooling system for a computer system, said computer system comprising
    - at least one unit such as a central processing unit (CPU) generating thermal energy and
  - 5 said cooling system intended for cooling the at least one processing unit and comprising
    - a reservoir having an amount of cooling liquid flowing through the reservoir from an inlet to an outlet of the reservoir, said cooling liquid intended for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid,
    - connections being provided between the inlet of the reservoir and a heat radiator and
  - 10 between the outlet of the reservoir and the heat radiator for conducting the cooling liquid from the heat radiator to the reservoir and from the reservoir to the heat radiator,
    - said cooling liquid communicating with channels or segments being provided inside the reservoir or being provided by making the surface of the heat exchanging surface plate inside the reservoir uneven or by adopting a certain shape of a heat sink with segments,
  - 15 - the heat exchanging interface intended for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid, when the cooling liquid passes the heat exchanging interface,
    - a pumping means being provided as part of an integrate element, said integrate element comprising the heat exchanging interface, the reservoir and the pump,
  - 20 - said pump intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means,
    - said pumping means, preferably an impeller, being mechanically integrate with a rotor of the pump and said pumping means being submerged in the cooling liquid of the reservoir,
    - said heat radiating means intended for radiating thermal energy from the cooling liquid,
  - 25 dissipated to the cooling liquid, to surroundings of the heat radiating means.
- 
2. A cooling system according to claim 1, wherein the pump is placed inside the reservoir with at least an inlet or an outlet leading to the cooling liquid in the reservoir.
- 
- 30 3. A cooling system according to claim 1, wherein the pump is placed outside the reservoir in the immediate vicinity of the reservoir and wherein at least an inlet or an outlet is leading directly to the cooling liquid in the reservoir.
- 
4. A cooling system according to any of the preceding claims, wherein an inlet of the pump
  - 35 is positioned in immediate vicinity of the heat exchanging interface for thereby obtaining a turbulence of flow of the cooling liquid in the immediate vicinity of the heat exchanging interface.

5. A cooling system according to any of the preceding claims, wherein an outlet of the pump is positioned in immediate vicinity of the heat exchanging interface for thereby obtaining a turbulence of flow of the cooling liquid in the immediate vicinity of the heat exchanging interface.
- 5
6. A cooling system according to any of the preceding claims, wherein a pumping member of the pump is positioned in immediate vicinity of the heat exchanging interface for thereby obtaining a turbulence of flow of the cooling liquid in the immediate vicinity of the heat exchanging interface.
- 10
7. A cooling system according to any of the preceding claims, wherein the pump is selected from the following types: Bellows pump, centrifugal pump, diaphragm pump, drum pump, flexible liner pump, flexible impeller pump, gear pump, peristaltic tubing pump, piston pump, processing cavity pump, pressure washer pump, rotary lobe pump, rotary vane pump and electro-kinetic pump.
- 15
8. A cooling system according to any of the preceding claims, wherein driving means for driving the pump is selected among the following driving means: electrically operated rotary motor, piezo-electrically operated motor, permanent magnet operated motor, fluid-operated motor, capacitor-operated motor.
- 20
9. A cooling system according to any of the preceding claims, wherein one or more of the following means are provided inside the reservoir for increasing the heat absorption by the cooling liquid: channels or segments inside the reservoir, an uneven surface being provided on a physical surface of the heat exchanging interface, a heat sink with segments provided inside the reservoir and being in thermal contact with the cooling liquid.
- 25
10. A cooling system according to any of the preceding claims, where the heat exchanging interface is a heat exchanging surface being in close thermal contact with the processing unit for dissipating heat from the processing unit to the cooling liquid via the heat exchanging surface.
- 30
11. A cooling system according to any of the preceding claims, where the heat exchanging interface is a free surface of the processing unit, said free surface of the processing unit having direct access to the cooling liquid for dissipating heat from the processing unit directly to the cooling liquid,
- 35
12. A cooling system for a computer system, said computer system comprising



- at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit and comprising
  - a reservoir having an amount of cooling liquid for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid,
- 5 - a heat exchanging interface for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid,
  - a pump intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means,
  - said cooling system being intended for thermal contact with the processing unit by means
- 10 of existing fastening means associated with the processing unit, and
  - said heat radiating means intended for radiating from the cooling liquid thermal energy, dissipated to the cooling liquid, to surroundings of the heat radiating means.
- 13. A cooling system according to claim 12, wherein the existing fastening means are
- 15 means intended for attaching a heat sink to the processing unit.
- 14. A cooling system according to claim 12, wherein the existing fastening means are means intended for attaching a cooling fan to the processing unit.
- 20 15. A cooling system according to claim 12, wherein the existing fastening means are means intended for attaching a heat sink together with a cooling fan to the processing unit.
- 16. A cooling system according to any of claims 12-15, wherein the pump is selected from
- 25 the following types: Bellows pump, centrifugal pump, diaphragm pump, drum pump, flexible liner pump, flexible impeller pump, gear pump, peristaltic tubing pump, piston pump, processing cavity pump, pressure washer pump, rotary lobe pump, rotary vane pump and electro-kinetic pump.
- 30 17. A cooling system according to any of claims 12-16, wherein driving means for driving the pump is selected among the following driving means: electrically operated rotary motor, piezo-electrically operated motor, permanent magnet operated motor, fluid-operated motor, capacitor-operated motor.
- 35 18. A cooling system according to any of claims 12-17, wherein one or more of the following means are provided inside the reservoir for increasing the heat absorption by the cooling liquid: channels or segments inside the reservoir, an uneven surface being provided on a physical surface of the heat exchanging interface, a heat sink with segments

provided inside the reservoir and being in thermal contact with the heat exchanging surface.

19. A cooling system according to any of claims 12-18, where the heat exchanging  
5 interface is a heat exchanging surface being in close thermal contact with the processing unit for dissipating heat from the processing unit to the cooling liquid via the heat exchanging surface.

20. A cooling system according to any of claims 12-18, where the heat exchanging  
10 interface is a free surface of the processing unit, said free surface of the processing unit having direct access to the cooling liquid for dissipating heat from the processing unit directly to the cooling liquid,

21. A cooling system for a computer system, said computer system comprising  
15 - at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit and comprising  
- a reservoir having an amount of cooling liquid for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid,  
- a heat exchanging interface for providing thermal contact with the processing unit and  
20 the cooling liquid for dissipating heat from the processing unit to the cooling liquid,  
- a pump intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means, and  
- said cooling system further comprising a pump wherein the pump is driven by an AC electrical motor powered by a DC electrical power supply of the computer system,  
25 - where at least part of the electrical power from said power supply is intended for being converted to AC being supplied to the electrical motor.

22. A cooling system according to claim 21, wherein the pump is selected from the following types: Bellows pump, centrifugal pump, diaphragm pump, drum pump, flexible  
30 liner pump, flexible impeller pump, gear pump, peristaltic tubing pump, piston pump, processing cavity pump, pressure washer pump, rotary lobe pump, rotary vane pump and electro-kinetic pump.

23. A cooling system according to claim 21 or 22, wherein one or more of the following  
35 means are provided inside the reservoir for increasing the heat absorption by the cooling liquid: channels or segments inside the reservoir, an uneven surface being provided on a physical surface of the heat exchanging interface, a heat sink with segments provided inside the reservoir and being in thermal contact with the heat exchanging surface.

24. A cooling system according to any of claims 21-23, where the heat exchanging interface is a heat exchanging surface being in close thermal contact with the processing unit for dissipating heat from the processing unit to the cooling liquid via the heat exchanging surface.

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25. A cooling system according to any of the claims 21-23, where the heat exchanging interface is a free surface of the processing unit, said free surface of the processing unit having direct access to the cooling liquid for dissipating heat from the processing unit directly to the cooling liquid,

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26. A cooling system according to any of the claims 1-25, wherein a motor is intended both for driving the pump for pumping the cooling liquid and for driving a fan for establishing a flow of air in the vicinity of the reservoir.

15 27. A cooling system according to any of the claims 1-25, wherein a motor is intended both for driving the pump for pumping the cooling liquid and for driving a fan for establishing a flow of air in the vicinity of the heat radiating means.

28. A cooling system according to any of the claims 1-25, wherein a motor is intended  
20 both for driving the pump for pumping the cooling liquid, and for driving the a fan for establishing a flow of air in the vicinity of the reservoir, and for driving a fan for establishing a flow of air in the vicinity of the heat radiating means.

29. A cooling system according to any of the preceding claims, wherein the heat  
25 exchanging interface is an element being separate from the reservoir, and where the heat exchanging interface is secured to the reservoir in a manner so that the heat exchanging interface constitutes part of the reservoir when being secured to the reservoir.

30. A cooling system according to any of claims 1-28, wherein the heat exchanging  
30 interface constitutes an integrate part of the reservoir, and where the heat exchanging interface extends along an area of a surface of the reservoir, said area of surface being intended for facing the processing unit and said area of surface being intended for close thermal contact with the processing unit.

35 31. A cooling system according to any of claims 1-28, wherein the heat exchanging interface is constituted between a free surface of the processing unit and the cooling liquid in the reservoir, and where the heat exchanging interface is capable of establishing the close thermal contact with the processing unit through an aperture provided in the

reservoir, and where the aperture extends along an area of the surface of the reservoir, said area of surface being intended for facing the processing unit.

32. A cooling system according to any of the preceding claims wherein said heat  
5 exchanging interface has an surface facing said reservoir, and said inside surface being substantially plane.

33. A cooling system for a computer system, said computer system comprising  
- at least one unit such as a central processing unit (CPU) generating thermal energy and  
10 said cooling system intended for cooling the at least one processing unit comprising  
- a reservoir having an amount of cooling liquid, said cooling liquid intended for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid,  
- a heat exchanging interface for providing thermal contact between the processing unit  
15 and the cooling liquid for dissipated heat from the processing unit to the cooling liquid,  
- a pumping means being intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means,  
- said heat radiating means intended for radiating thermal energy from the cooling liquid, dissipated to the cooling liquid, to surroundings of the heat radiating means,- said heat  
20 exchanging interface being manufactured from a material suitable for heat conducting, and  
- with a first side of the heat exchanging interface facing the central processing unit being substantially plane and  
- with a second side of the heat exchanging interface facing the cooling liquid being substantially plane and  
25 - said reservoir being manufactured from plastic, and channels or segments being provided in the reservoir for establishing a certain flow-path for the cooling liquid through the reservoir.

34. A cooling system according to claim 33, wherein said pumping means is provided as  
30 part of an integrate element, said integrate element comprising the heat exchanging interface, the reservoir and the pumping means. 35. A cooling system according to claim 33 or 34, wherein an inlet of said pumping means is positioned in immediate vicinity of the heat exchanging interface for thereby obtaining a turbulence of flow of the cooling liquid in the immediate vicinity of the heat exchanging interface.

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36. A cooling system according to claim 33 or 34, wherein an outlet of said pumping means is positioned in immediate vicinity of the heat exchanging interface for thereby obtaining a turbulence of flow of the cooling liquid in the immediate vicinity of the heat exchange interface.

37. A cooling system according to claim 33 or 34, wherein a pumping member of said pumping means is positioned in immediate vicinity of the heat exchanging interface for thereby obtaining a turbulence of flow of the cooling liquid in the immediate vicinity of the  
5 heat exchanging interface.

38. A cooling system according to any of claims 33-37, wherein the pumping means is selected from the following types: Bellows pump, centrifugal pump, diaphragm pump, drum pump, flexible liner pump, flexible impeller pump, gear pump, peristaltic tubing  
10 pump, piston pump, processing cavity pump, pressure washer pump, rotary lobe pump, rotary vane pump and electro-kinetic pump.

39. A cooling system according to any of claims 33-38, wherein driving means for driving the pump is selected among the following driving means: electrically operated rotary  
15 motor, piezo-electrically operated motor, permanent magnet operated motor, fluid-operated motor, capacitor-operated motor.

40. A cooling system according to any of claims 33-39, wherein said pumping means is driven by an AC electrical motor by a DC electrical power supply of the computer system,  
20 wherein at least part of the electrical power from said power supply is intended for being converted to AC being supplied to the electrical motor.

41. A cooling system according to any of claims 33-40, where the heat exchanging interface is a heat exchanging surface being in close thermal contact with the processing  
25 unit for dissipating heat from the processing unit to the cooling liquid via the heat exchanging surface.

42. A cooling system according to any of claims 33-40, where the heat exchanging interface is a free surface of the processing unit, said free surface of the processing unit  
30 having direct access to the cooling liquid for dissipating heat from the processing unit directly to the cooling liquid,

43. A cooling system for a computer system, said computer system comprising  
- at least one unit such as a central processing unit (CPU) generating thermal energy and  
35 said cooling system intended for cooling the at least one processing unit comprising  
- at least one liquid reservoir mainly for dissipating or radiating heat, said heat being accumulated and transferred by said cooling liquid,  
- said cooling system being adapted such as to provide transfer of said heat from a heat dissipating interface to a heat radiating surface where

- said at least one liquid reservoir being provided with one aperture intended for being closed by placing said aperture covering part of, alternatively covering the whole of, the at least one processing unit in such a way that a free surface of the processing unit is in direct heat exchanging contact with an interior of the reservoir, and thus in direct heat exchanging contact with the cooling liquid in the reservoir, through the aperture.

44. A cooling system for a computer system according to claim 43, wherein the aperture of the reservoir is intended for being closed by attaching boundaries of said aperture to a free surface of a the processing unit.

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45. A cooling system for a computer system according to claim 43, wherein the aperture of the reservoir is intended for being closed by attaching boundaries of said aperture along boundaries of a free surface of the processing unit.

- 15 46. A cooling system for a computer system according to claim 43, wherein the aperture of the reservoir is intended for being closed by attaching boundaries of said aperture to a free surface of a heat sink.

- 20 47. A cooling system for a computer system according to claim 43, wherein the aperture of the reservoir is intended for being closed by attaching boundaries of said aperture along boundaries of a free surface of a heat sink.

48. A cooling system according to claim 43, wherein

- 25 - a first reservoir is intended for being closed by attaching boundaries of an aperture in the first reservoir to, alternatively along, a free surface of a said processing unit and wherein  
- a second reservoir is intended for being closed by attaching boundaries of an aperture in the second reservoir to, alternatively along, a free surface of a to a free surface of a heat sink, and where  
- liquid conducting means are provided between the first reservoir and the second  
30 reservoir.

49. A cooling system according to claim 43, wherein a first reservoir is closed by attaching said first reservoir to a heat exchanging surface element being in close thermal contact with the processing unit, said heat exchanging surface intended for dissipating heat from  
35 the processing unit to cooling liquid in the first reservoir, and wherein a second reservoir is closed by attaching said second reservoir to a surface of a heat sink, said heat sink intended for radiating heat from cooling liquid in the second reservoir to the exterior surroundings.

50. A cooling system according to claim 48 or 49, wherein said first reservoir and said second reservoir are provided as a monolithic structure comprising both the first reservoir and the second reservoir and where both a heat dissipation from the processing unit to the cooling liquid in the first reservoir and heat radiation from the cooling liquid in the second reservoir to exterior surrounding is provided by the monolithic structure.

51. A cooling system according to claim 50, wherein said monolithic structure is manufactured at least partly from plastic, preferably is manufactured fully in plastic, and said monolithic structure being manufactured by injection moulding.

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52. A cooling system according to any of claims 43-51, wherein transfer of said cooling liquid from an outlet of the first reservoir to an inlet of the second reservoir, and from an outlet of the second reservoir to an inlet of the first reservoir, and circulating the cooling liquid within said liquid conducting means is provided by a pumping means being intended for pumping the cooling liquid.

53. A cooling system according to any of claims 43-52 wherein one of said reservoirs of said monolithic structure comprises said pumping means.

20 54. A cooling system according to claim 52 or 53, wherein an inlet and/or an outlet and/or a pumping member of said pumping means, is provided in the vicinity of said substantially plane side in order to provide a turbulence of flow and hereby improve the exchange of heat between said cooling liquid and substantially plane side.

25 55. A cooling system according to claim 54, wherein an inlet of the pumping means is provided within the first reservoir and the outlet is provided within the second reservoir.

56. A cooling system according to any of the claims 43-55, wherein the pump is selected from the following types: Bellows pump, centrifugal pump, diaphragm pump, drum pump, flexible liner pump, flexible impeller pump, gear pump, peristaltic tubing pump, piston pump, processing cavity pump, pressure washer pump, rotary lobe pump, rotary vane pump and electro-kinetic pump.

57. A cooling system according to any of the claims 43-56, wherein driving means for driving the pump is selected among the following driving means: electrically operated rotary motor, piezo-electrically operated motor, permanent magnet operated motor, fluid-operated motor, capacitor-operated motor.

58. A cooling system according to any of claims 43-57, wherein said pumping means is driven by an AC electrical motor by a DC electrical power supply of the computer system, wherein at least part of the electrical power from said power supply is intended for being converted to AC being supplied to the electrical motor.

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59. A cooling system according to any of claims 43-58, wherein one or more of the following means are provided inside the reservoir for increasing the heat absorption by the cooling liquid: channels or segments inside the reservoir, an uneven surface being provided on a physical surface of the heat exchanging interface, a heat sink with segments provided inside the reservoir and being in thermal contact with the heat exchanging interface.

60. A cooling system according to any of claims 43-59, wherein an electrical motor is intended both for driving the pump for pumping the cooling liquid through the reservoir and for driving a fan for establishing a flow of air around the reservoir.

61. A cooling system according to any of claims 43-59, wherein an electrical motor is intended both for driving the pump for pumping the cooling liquid through the reservoir and for driving a fan for establishing a flow of air along heat radiating means.

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62. A cooling system according to any of claims 43-59, wherein an electrical motor is intended both for driving the pump for pumping the cooling liquid through the reservoir, and for driving a fan for establishing a flow of air around the reservoir, and for driving a fan for establishing a flow of air along heat radiating means.

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63. A method of cooling a computer system comprising at least one unit such as a central processing unit (CPU) generating thermal energy and said method utilising a cooling system for cooling the at least one processing unit and, said cooling system comprising

- a reservoir
- 30 - at least one heat exchanging interface
- an air blowing fan
- a pumping means

said method of cooling comprising the steps of

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- applying one of the following possibilities of how to operate the computer system: establishing, or defining, or selecting an operative status of the computer system
- controlling the operation of at least one of the following means of the computer system; the pumping means and the air blowing fan in response to at least one of the following



parameters; a surface temperature of the heat generating processing unit, an internal temperature of the heat generating processing unit, or a processing load of the CPU and

- In accordance with the operative status being established, defined or selected, controlling
- 5 the operation of the computer system in order to achieve at least one of the following conditions; a certain cooling performance of the cooling system, a certain electrical consumption of the cooling system, a certain noise level of the cooling system.

64. A method according to claim 63 for cooling a computer system, wherein the operation
- 10 of the air blowing fan is controlled before any control of the operation of the pumping means in order to achieve the at least one selected condition of the cooling system.

65. A method according to claim 63 or 64 for cooling a computer system, wherein said computer system further comprises an operative system or an alike means comprising a
- 15 means for measuring the CPU load and/or the CPU temperature, and wherein said method of cooling said CPU further comprises the step of
- using a measurement, performed by said BIOS or alike means, of the CPU load and/or the CPU temperature for controlling said cooling system.

- 20 66. A method according to claim 63 for cooling a computer system, wherein said cooling system further comprises a temperature measuring means for measuring a temperature of the CPU, and wherein said method of cooling said CPU further comprises the step of
- using a measurement, performed by said temperature measurement means, of the CPU temperature for controlling said cooling system.

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67. A method for cooling a computer system, wherein said cooling system further comprises a pumping means with an impeller for pumping the cooling liquid through a pumping housing, said pumping means being driven by an AC electrical motor with a stator and a rotor, and said pumping means being provided with a means for sensing a
- 30 position of the rotor, and wherein the method comprises the following steps- initially establishing a preferred rotational direction of the rotor of the electrical motor
- before start of the electrical motor, sensing the angular position of the rotor
  - during start, applying an electrical AC voltage to the electrical motor and selecting the signal value, positive or negative, of the AC voltage at start of the electrical motor
- 35 - said selection being made according to the preferred rotational direction, and
- said application of the AC voltage being performed by the computer system for applying the AC voltage from the electrical power supply of the computer system during conversions of the electrical DC voltage of the power supply to AC voltage for the electrical motor.

68. A method according to claim 67, where sensing the angular position of the rotor is accomplished by a number Hall-sensors placed at angular intervals for detection of the rotor's magnetic poles, the number of sensors corresponding to the number of magnetic  
5 poles establishing the mechanical angle, and corresponding to the electrical angle.

69. A method according to claim 67 or claim 68, where application of the electrical AC voltage to the electrical motor and selection of the signal value, positive or negative, of the AC voltage at start of the electrical motor is accomplished by the operating system of the  
10 computer system and is communicated to an DC/AC converter of the computer system.